PLANT EXPLORATION REPORT

for

SAFFLOWER AND MISCELLANEOUS OILSEEDS

NEAR EAST and MEDITERRANEAN COUNTRIES

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INTRODUCTION

This is an informal report covering the observations made and plant materials collected in Afghanistan, Egypt, India, Iran, Iraq, Israel, Jordan, Morocco, Pakistan, Portugal, Spain, Syria and Turkey. The information herein is strictly for reference purposes whenever additional exploration may be planned in the same areas, or as a working tool when associated official business pertains.

Major emphasis was placed on collecting germ plasm for safflower breeders, but in addition numerous samples of Brassica, Helianthus, Linum, Ricinus and Sesamum and miscellaneous oilseeds were obtained when opportunity afforded. Lesser numbers of vegetables, forage legumes and grasses, and miscellaneous crops were also collected. A complete indexing by species name and Plant Introduction (PI) numbers appears at the end of the report (pages 30-42).

JUSTIFICATION

Both the success and the shortcomings of safflower (Carthamus tinctorius L.) indicated the need for a collection trip to find new varieties. With the development of "Nebraska" varieties having a high oil content, safflower showed promise as an oil crop in the western part of the Northern Great Plains. Since 1950 it has been an established oil crop in California, with the area of production in 1957 being about 70,000 acres. Though the oil was used primarily in paints and varnishes, a small amount was being marketed for edible purposes. Details of its development may be found elsewhere (2, 3, 4, 5).*

Its area of adaptation, however, had proved to be rather limited. As an irrigated crop it had not been too successful, since slight excesses of water either killed the plants directly or encouraged the development of root rotting diseases. In areas of high humidities foliar diseases were serious. Only in the Sacramento Valley of California had it been distinctly successful. This perhaps was not surprising, since all varieties grown in the United States had stemmed from introductions from an area with a climate similar to that of the Sacramento Valley.

Though several varieties of safflower had been obtained from abroad by plant explorers or by correspondence, there was a distinct need for a systematic search for more materials. This was made even more imperative by the knowledge that the culture of safflower had been, or was being, abandoned in some countries. Kupsow's report (7) indicated that there were varieties which had not been introduced into the United States.

There was also a need for collections of wild species of safflower. There are some 25 species in the Carthamus genus, but only 11 had been grown at the University of California. Some research has been done on these by Ashri (1), enough to indicate both that the genus provides interesting possibilities in studies of species relationships and that the wild species may be useful in the improvement of cultivated safflower. Because of their spiny and weedy characteristics, plant explorers have passed them by.

This collection trip was made, therefore, with two primary purposes. The first was to collect and study the distribution of cultivated safflower. The second purpose was the same but applied to the wild species. It was intended that something should be learned of the culture and utilization of safflower. Other species of domestic and wild plants were to be collected also, as they were met in the search for safflower.

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* Numbers in parenthesis refer to the literature list(page 29).

The trip was financed jointly by the University of California and the U. S. Department of Agriculture, the former paying salary and the latter traveling expenses.

Reports of visits to the separate countries have been filed with the Plant Introduction Section, New Crops Research Branch, Crops Research Division, ARS, USDA, Beltsville, Maryland. In some respects these will be summarized here, in other respects expanded upon.

ITINERARY

The trip was planned to permit collections in areas of Asia, Europe and Africa where safflower was known to be grown or to have been grown in the past. The itinerary was designed to allow seed collections of both cultivated and wild safflower as they approached maturity. This required that a circuitous route be followed with the warmer areas being visited first. It was necessary to revise the itinerary as the trip progressed.

Several herbaria were visited, most of them prior to collections in the field. The writer is much indebted to personnel of these herbaria for the opportunity to study and, in some cases, to photograph Carthamus materials. These studies permitted me to become familiar with wild species which had not been seen previously, and indicated areas where and when they might be found. The herbaria visited and their locations are given below:

U. S. National Herbarium, Smithsonian Institution, Washington, D. C., March 6, 7.

New York Botanical Garden, Bronx Park, New York, N.Y., March 10.

Royal Botanic Garden, Edinburgh, Scotland, March 12, 13, 14.

Royal Botanic Garden, Kew, Surrey, England, March 17, 18, 19, 20.

Linnaean Herbarium, Burlington House, London, England, March 19.

British Museum, London, England, March 21.

Museum Nationale d'Histoire Naturelle, Paris, France, March 24, 25.

Gordon College, Rawalpindi, Pakistan, May 5.

Abu Ghraib Experiment Station, Baghdad, Iraq, June 5.

University College of Arts and Science, Baghdad, Iraq, June 9.

University of Cairo, Cairo, Egypt, June 16.

Deir Alla Station, Ministry of Agriculture, Jordan, June 21.

University of Ankara, Ankara, Turkey, August 13.

Hebrew University, Jerusalem, Israel, August 26.

Institut Scientifique Cherifien, Rabat, Morocco, September 3.

Jardin Botanico, Madrid, Spain, September 11.

Estacao Agronomica Nacional, Sacavem, Portugal, September 22.

Jardin Botanique, Geneva, Switzerland, October 1, 2, 3.

Herbaria that were visited before the collection trip are as follows:

Dudley Herbarium, Natural History Museum, Stanford University, Stanford, California.

The California Academy of Sciences, Golden Gate Park, San Francisco, California.

The University of California, Berkeley, California.

The State Department of Agriculture, Sacramento, California.

Rancho Santa Ana Botanic Garden, Claremont, California.

Visits to the countries where seed collections were obtained were made on the following schedule:

India (Delhi, Pusa, Hyderabad, Poona, Amritsar): April 4-24, May 21.

Pakistan (Lahore, Lyallpur, Gujrat, Rawalpindi, Peshawar, Karachi): April 25-May 20, May 22-24.

Afghanistan (Kandahar, Lashkar Gah -- Southern areas): May 25-29.

Iran (Tehran, Abadan, Ahvaz, Dizful -- southern areas): May 30-June 4.

Iraq (Baghdad, Hilla, desert west of Ramadi -- southern areas): June 5-10.

Egypt (Cairo, Alexandria, Kena, Luxor, Sohag, Assiut): June 11-20.

Jordan (Amman, Deir Alla Station, Nablus, Jerusalem): June 21-24.

Syria (Damascus, Aleppo): June 25-28.

Iraq (Mosul, Salahudin, Sirsank, Kirkuk, Sulaimaniya -- northern areas): June 29-July 9.

Iran (Tehran, Isfahan, Tabriz, Meshed): July 10-31.

Afghanistan (Kabul, Ghazni, Dasht-i-Nawar, Charikar -- central areas): August 1-10.

Iran (Tehran): August 11.

Turkey (Ankara, Gokhoyuk, Amasya, Tokat, Yozgat, Eskisehir, Bursa, Balikesir, Izmir, Istanbul): August 12-24.

Israel (Tel Aviv, Jerusalem, Beersheba, Tiberias, Nazareth, Safad, Acre, Haifa): August 25-31.

France (Paris): September 1.

Morocco (Rabat, Oujda, Melilla, Casablanca, Tadla, Bine el Quidane, Meknes): September 2-9.

Spain (Madrid, Cuenca, Teruel, Albacete, Alicante, Elche, Murcia, Granada, Malaga, Seville, Trujillo): September 10-20, 25-26.

Portugal (Lisbon, Sacavem, Oeiras): September 21-24.

Spain, Switzerland, Italy -- on vacation: September 25 - October 15.

Greece (Athens, Corinth, Tripolis, Olympia, Delphi, Larissa) -- on vacation: October 15-25.

In retrospect one can see shortcomings in this itinerary. Many areas where cultivated safflower has been reported were not visited, were visited too briefly, or were visited at the wrong time of year. It is hoped that future plant explorations will provide materials from these areas. A

list of these areas and the time of year when collections should be made is given below:

Country or Area	Time of Year
India: Bihar State	March
India: Bombay State	March
Northwest area	March-April
Burma	March-April
Southeast Asia	March
Philippine Islands	February and March
Siberia: East of Caspian Sea to Tashkent	Early August
Russia: Caucasus area	Early August
Afghanistan: Northern frontier	Late August
Herat area	Late August
Pakistan: Hyderabad area	March
Kashmir and Nepal	Late August
Iran: Areas other than Meshed, Tabriz, Tehran, Isfahan and the Khuzestan	Late July and August
Turkey: Eastern area	Late August
Lebanon: Lower elevations	Late June
Higher elevations	Late July
Egypt: Lower Egypt between the Sudan and Luxor	Late April - Early May
Sudan	February - March
Ethiopia	January - February
Morocco, Algeria and Tunisia	July - August
Spain: Cuenca, Valencia, Murcia, and Alicante area, or any location growing saffron	Late July
Portugal: Southern areas	July

There are even more serious gaps in collections of wild species. A list is given below of areas where the missing or scarce wild species may be found:

Species	Country or Area	Time of Year
C. leucocaulos Sibth & Sm.	Crete, Cyprus, Aegean Islands	Late July Early August
C. boissieri Hal.	Crete	July, August
C. rechingeri Davis	Karpathos Island	July, August
C. mareoticus Del.	Egypt, west of Alexandria	April, May
*C. caeruleus L.	Mostly the islands and margins of the western part of the Mediterranean Sea, but some in the eastern Mediterranean.	June, July
C. calvus (B. & R.) Batt.	Algeria and Morocco	June, July
C. helenoides Desf.	Algeria, northern part	June, July
C. carthamoides (Pomel.) Batt.	Algeria, northern part	August

* Often considered to be Carduncellus species.

*C. pectinatus Desf.	Algeria, northern part	August
*C. multifidus Desf.	Algeria	August
*C. mitissimus (L.) DC.	Spain and France	August
C. fruticosus Maire	Morocco	July
C. rifeus (P. & F.Q.) F.Q.	Morocco	July

* Often considered to be Carduncellus species.

Considering the large number of countries visited, the itinerary could not have been improved very much within the limits of the time available. Usually the cultivated safflower was obtained shortly before, or just after, harvest. Had India and Pakistan been visited earlier to obtain cultivated safflower in the field, it would have been too early to collect seed of wild species. The same is true of Egypt where the cultivated safflower had been harvested, and the first heads of wild species just beginning to mature.

Arrangements for travel within the several countries varied greatly. Travel by car was usually obtained through the U. S. Agricultural Attache, USOM headquarters or the Ministries of Agriculture. Many persons, too numerous to list here, gave generously of their time to assist in obtaining seed collections. Several American families stationed in towns where good hotels were unavailable, provided food and lodging. For their help and hospitality the writer is most grateful.

CULTIVATED SAFFLOWER

Collections:

The collections of seed of safflower are listed in table 1. It is expected that more samples will be received from some countries, and particularly from India, Iran and Afghanistan.

Many of the samples were obtained from research stations, and where they were obtained from two stations in the same country there may be duplications.

Bazaars were the source of many samples. Unfortunately, little information could be obtained on the origin of such materials, though in many cases they probably were local types. However, most towns visited in Pakistan had safflower seed in bazaars, but only the Gujrat area was reported to grow it. It is likely with some of these Pakistan materials that they were imported from India -- it was so reported by one shopkeeper. In each town several shops may have obtained their seed from the same sources, though usually there was some variation from sample to sample.

From country to country different types of stores sold safflower seed. In India and Pakistan, and to some extent in Iran and Iraq, it was sold by the merchants handling local remedies, which included bark,

(cont'd. page 8)

Table 1. Collections of seed of cultivated safflower in different countries in 1958.

Country	Area	Number of Collections	Remarks
India	Pusa Station	30	
	Hyderabad	88	34 from Rajenderonayer Sta.
	Poona	0	Seed samples to be sent later
	Amritsar	7	From bazaars
	Delhi	0	
	Total	125	
Pakistan	Lahore	9	All from bazaars
	Lyallpur	14	From Lyallpur Station
	Gujrat	24	From bazaars and farmers
	Rawalpindi	13	From bazaars
	Peshawar	3	From bazaars
	Karachi	12	From bazaars
	Total	75	
Afghanistan	Kandahar	0	
	Lashkar Gah	0	
	Kabul	15	From bazaars and fields
	Ghazni	1	From a border of a field
	Total	16	
Iran	Tehran	10	From bazaars and Karaj Sta.
	Khuzestan	0	
	Isfahan	22	From bazaars and fields
	Tabriz	7	From bazaars and homes
	Meshed	14	From bazaars and fields
	Total	53	
Iraq	Baghdad	4	From bazaars - origin Iran?
	Mosul	0	
	Sulaimaniya	0	
	Total	4	
Jordan	Amman-Jerusalem	13	Mostly from fields
Syria	Damascus-Aleppo	6	From bazaars
Israel	Near Jerusalem	1	From a villager
	Near Nazareth	3	From villagers
	Total	4	

Table 1. Continued

Country	Area	Number of Collections	Remarks
Turkey	Univ. of Ankara	3	
	Eskisehir Expt. Sta.	7	
	Eskisehir area	4	Farmers' fields
	Belikesir area	1	Farmer's field
	Total	15	
Greece	Larissa Station	1	From Turkey
Egypt	Cairo	7	From bazaars
	Giza Station	2	
	Near Giza	2	
	Alexandria	2	Bazaar and Expt. Sta.
	Kena	15	Warehouses
	Near Luxor	1	Farmer
	Sohag	4	Oilseed mill and farms
	Assiut	3	Bazaar and oilseed mill
	Total	36	
Morocco		0	
Spain	Cuenca area	5	Jefatura Agronomica
	Teruel area	2	Villagers
	Alicante	1	Seed store
	Elche	2	Seed store
	Southern Spain	0	
	Total	10	
Portugal	Southern part	10	Sacavem Station
	Herbaria of Asia & Europe	52	Sacavem Station
	Total	62	
Total all countries		420	

roots, leaves, petals, and other plant parts. In Egypt and Syria it was included with the seeds of other field crops. In Tehran it was often with the flower seeds.

Until the collected materials are grown and their characteristics recorded, it will not be possible to make firm or extensive statements on the nature of the variability. Such observations or conclusions as are available now are given below:

(1) Most Indian and Pakistan materials are spiny. This provides protection against bird damage and makes safflower more useful as a hedge to protect other crops from stray animals. Those of Iran, Syria, Jordan, Israel, Spain and Portugal were usually spineless or almost so. This might be expected because safflower is used in these countries for its flowers. Both spiny and spineless types were present in Egypt and Afghanistan. Both types were present also in Turkey, but the spines were not pronounced, and the spiny types had larger heads and were more vigorous.

(2) Red or orange flowers were most common, and red was seen most often where safflower was grown for its flowers. Red, orange and yellow flowers were present in Egypt, Turkey, Afghanistan and India.

(3) The amount of branching was greatest in Indian varieties.

(4) Tallest types were seen in Upper Egypt, where they were about five feet high. Near Isfahan, Iran, a few plants were found that were about five feet tall -- the height of most plants was about 30 inches. These tall plants were not in bloom, while the earliest heads of the normal plants approached maturity.

(5) There was considerable variation in size and shape of seeds, but nothing beyond the range of types already introduced to the United States. Seed obtained from bazaars in Pakistan was very dark in color in a few instances, presumably the effect of weathering or poor storage conditions. Where plants were seen, the variability was different in different areas.

(6) "Nebraska" varieties from the United States were seen occasionally. At the Pusa Station in Bihar State of India these looked better than the local types in the nursery. But at the Agricultural Research Institute, at Rajenderanayer, near Hyderabad, India, the Nebraska varieties were reported to be lower in yield than Indian varieties. The thin stands that were used gave considerable advantage to the Indian types which develop more branches than Nebraska varieties. Two introductions from the United States growing in the nursery at the Agricultural College at Lyallpur, Pakistan, were severely attacked by larvae of the safflower fly, but these had been planted later than other safflower materials. At the Deir Alla Station in Jordan the local variety appeared superior to those introduced from the U.S., and the same was true at Rehovot, Israel, and Karaj, Iran.

(7) Abnormal types were seen sometimes. All safflower plantings in the Kabul area of Afghanistan had some of the flowers modified into vegetative structures. Often the first head or the first few heads of affected plants were normal, which would suggest that it was some environmental influence, and it is believed that it is the effect of attack by some insect. These vegetative structures involved the elongation of the ovary, and sometimes the production of a small head at the tip of this ovary. At the Deir Alla Station in Jordan a few safflower heads had developed vegetatively, but not to the same extent as those seen in Afghanistan. Near this station two safflower plants were seen with numerous tiny leaves and no heads.

(8) A few natural hybrids of tinctorius with other species were seen. At the Abu Ghraib Station in Iraq a presumed natural hybrid with oxyacantha was seen among some C. oxyacantha -- this plant was taller than the wild species and intermediate in appearance between the parents. A similar intermediate was seen in cultivated safflower east of Isfahan in Iran, with the wild species nearby. Near the Deir Alla Station in Jordan, abnormal sterile types were assumed to be hybrids with glaucus or syriacus. They had the grey-green color of the latter species, yet were found in rows of cultivated safflower. At the Agricultural Experiment Station, Eskisehir, Turkey, some off-type plants of tinctorius were believed to be natural hybrids with flavescens, a common weed in Turkey -- they were intermediate between the presumed parents. In Pakistan, where tinctorius and oxyacantha occurred together, hybridization would be rare because the former was mature and harvested before the latter started to bloom.

Status of safflower

As an oil crop in India the acreage of safflower probably has not changed greatly in recent years, but over the last century there has been some important changes in the area of safflower grown for the extracted dye. In fact the writer found no safflower used for this purpose, when large acreages must have been grown a century ago. In Pakistan it was reported to be a disappearing crop, and hangs on only in the Gujrat areas as a forage crop.

It was not possible to learn anything about changes in the status of safflower in most of the Middle East, but it would appear that it is disappearing here also. Certainly synthetic dyes are available everywhere, and no evidence was found of the flowers of safflower being processed to make dye. A cheap substitute source of coloring for food might eliminate safflower altogether from Iran and other countries not using it for oil.

It was surprising to find no cultivated safflower in Iraq -- those obtained in Baghdad and Hilla are believed to be imported from Iran. This was true also of the Khuzestan, an area of Iran continguous with Iraq. The seed in the bazaars was sold for medicinal purposes, and not to be sown. Wild safflower (oxyacantha), however, was abundant in much of Iraq and the Khuzestan.

Acreage statistics in Turkey over the last six years seem to indicate that (1) the acreage is decreasing, (2) the area of production shifts to some extent from year to year, and (3) the province of Eskisehir has produced the largest amount. The acreage in Egypt has probably fluctuated greatly, but is decreasing now because of the increasing acreages of cotton.

Herbarium studies

From herbaria visited in the United States and other countries it was possible to get some information on the distribution of different types of cultivated safflower. Admittedly such evidence is rather fragmentary, but it is probably the best we have for the 19th century. Conclusions and observations for a study of herbaria materials are as follows:

(1) Safflower was or is established over a wider area than the literature had stated or implied. As expected, specimens were present in large numbers from India and Pakistan. Nor was it surprising to find specimens from countries adjacent to India, from the Middle or Near East, and from countries bordering on the Nile River. Areas distant from the above where safflower specimens had been collected were:

China: Peking, Szechwan (1890), West Hupeh, Kansou (1918).
Philippine Islands: Luzon (1855).
East Indies: Java, Batavia.
Japan: Yokohama (1907), no location (1861).
Burma: Sagaing (1893).
Korea: Herschel Island, Saul (1884).
Siam: Mekor (1915).
Cochin-China: No location.
Indo-China: Lower Laos (1870s).
Mongolia: No location (1865).
Canary Island: Mogan (1862).

No specimens were seen from the Sudan or Turkey where several different introductions have been obtained by both the U.S.D.A. and the University of California. Types established in moist areas such as the Philippines, the East Indies and perhaps also in Burma, Indo-China and Cochin-China should have resistance to foliar diseases, if humidities are high in these areas. Such resistance has been absent from most safflower introductions.

(2) The head size of most materials was about the same, allowing for differences in stage of development, with the diameter of the heads being less than one inch. As expected, some specimens from Egypt and Afghanistan had heads with diameters between one and one and one-quarter inches. One specimen from El Duvan, about 200 km. south of Aswan in Egypt, had a head diameter of about 2 inches. This was a distinct type with large, spineless, ovate outer bracts, and short inner bracts. Its flowers were an intense red, and it apparently was grown for oil.

(3) In most areas where specimens were obtained, both spined and spineless types were present. Where both were present there were more spineless types, probably because they either were preferred for production of flowers or were easier for botanists to handle. In Japan, Korea, the East Indies and Southeast Asia only spiny types were found, and from China there were more spiny specimens than spineless. Only spiny types were obtained from Ethiopia, and all of these appeared similar to recent introductions from that country. All specimens from the Arabian Peninsula were spineless, and this was true of all but one specimen from the Middle and Near East.

(4) All specimens had flowers that were orange or red in color — it was difficult to distinguish between red and orange in many cases. The absence of types with yellow flowers is not too surprising because most specimens represent types that were grown for the red dye in the flowers.

(5) Only two specimens had rust, and they came from the Arabian towns of Kuwait and Anaiza.

(6) Some specimens collected in Afghanistan (year not indicated) had the inflorescence modified so that it appeared as a group of small branches -- they were similar to those actually seen in the same area. In fact, the writer was on the lookout for this condition in safflower after seeing it in a herbarium specimen.

Culture

Considering that safflower is grown over a vast area with wide differences in climate, it is not surprising that details of its culture vary considerably. These details will not be presented here; only general observations will be given.

In general safflower is a minor crop, and usually it is sown with, or as a border to, other crops. In India and Pakistan it is a rabi crop, one that is grown from September to March through the cool, dry season of the year. It is grown with vegetable or field crops such as wheat, barley, pigeon pea, chick pea, castor beans or spinach. In much of the Middle East it was associated with chick peas, onions, cotton and melons, usually as a border. Though sown with, or as a border to, other crops, it was harvested separately. Where it was grown broadcast with another crop, the stands of safflower were thin. Even when grown in rows the stands were thinner than is usually the case in the United States. In the Hyderabad area of India, when the plants were grown in rows 24 to 30 inches apart, the plants were nine to 12 inches apart in the row. This wide spacing puts a premium on abundant branching, and may explain why Indian varieties are bushy in nature. Seeding rates vary from 4 to 20 pounds per acre. However, with quite a different type of plant, plant spacings were about the same in Israel and Jordan.

Only in a few countries was safflower grown on a field scale. Small fields about two acres in size were seen in Afghanistan, and up

to 20 acres in Turkey. Though it was not seen, Israel grows some safflower on a field scale.

Mostly safflower is a dryland crop. In India and Pakistan it is planted in September and October, after the monsoon season, and harvested in March and April, well before the monsoon season of the next year. In Iran and Afghanistan it is sown in the spring after the winter precipitation. The same is true in Turkey where it is grown as a substitute for wheat or barley. It is sown in October or November in Egypt after the flood waters of the Nile have receded. In Syria it is spring sown, and in Jordan is sown in the winter at lower elevations and in the spring at higher elevations. February has been the best month for planting in Israel. In Spain and Portugal it has been sown in the early spring. In all of these areas there is little or no rain falling on the growing crop.

If safflower is grown with an irrigated crop, and this is frequently the case in the Middle East, it receives the benefit of some irrigation, but in such cases it is usually grown on the ridge surrounding the main crop. It was reported to me that it was sometimes irrigated before the flowering stage in the Hyderabad area of India without Phytophthora root rot being observed. Other areas of India may also grow it under irrigation. In Pakistan the safflower and wheat mixture is given one irrigation when the safflower is about knee high. During a dry spring in Israel an irrigation may be given just before flowering. In Portugal where it is grown in small patches it may be irrigated. In the Sohag area of Upper Egypt the irrigation schedule for safflower is as follows: first irrigation, 40 days after planting; second irrigation, 70 days after planting; and the third irrigation, if needed, 95 to 100 days after planting.

Safflower is usually grown on fertile soils. In many areas this is coincidental to its use as a border crop for vegetable crops. In the Hyderabad area of India it was grown on the heavy clay black soils. These soils have excellent water-holding capacity, and often had cracks four inches wide.

Mostly it was harvested by hand, and the seeds beaten out of the heads with sticks. Exceptions to this practice would be in Israel and Turkey, where modern harvesting equipment was used.

Uses

Most of the safflower grown in India is used as an edible oil, and the oil is consumed locally. In the Hyderabad area it is considered to rank just below sesame oil in quality. It is also used as a source of oil in Turkey, Israel, Egypt and Afghanistan.

In Iran, Jordan, Syria, Israel, Egypt, Spain and Portugal it is grown primarily for the flowers. The flowers are dried and used to color foods, often as a substitute for saffron. Foods that may be colored with the flowers of safflower are rice, the surface of loaves of bread, and pickles. A herbarium sheet mentioned that in Kuwait the dried petals are mixed with dried rose petals as a woman's hair wash. It

was not seen being used for the extracted dye, but it is reported to be used for that purpose in Egypt.

The seed was often used to feed birds. It was on sale in Cairo as feed for "big birds", presumably parrots. In Isfahan, Iran, much of the production was fed to pigeons. In Kabul, Afghanistan, the hull was knocked off most of the seeds before selling them as feed for small caged birds. In Spain it was reported that those persons who hunted birds with nets and live decoys valued safflower because it prevented the high mortality of several species of decoys during the winter and molting periods. Seed not used for planting the next year's crop in Portugal was fed to poultry.

In the Gujrat area of West Pakistan safflower plants were pulled while still green and fed to livestock. For this purpose it was usually planted with wheat, the seeding rate being down to eight pounds per acre, and the rows spaced two or more feet apart. Some thought was being given to the use of the spineless type for this purpose in India, though it was felt that the villager would not accept a crop grown for its forage alone.

The seed was used in India and West Pakistan as an ingredient of a preparation to prevent abortion and to delay menopause. In Tabriz, Iran, it was reported that after boiling safflower seed in water the liquid could be used to induce vomiting.

Processing for oil

All of the equipment seen for extracting safflower oil was primitive in nature. In India such equipment is called a ghani, and in Pakistan a kohlu. It operates on the mortar and pestle principle. The safflower seed, whole or after grinding between flat stones, is placed in a deep wooden "mortar" -- it varies in inside diameter from 6 to 12 inches, and in inside depth from 15 to 30 inches. A wooden pole or "pestle" sits in the mortar and is turned by a horizontal shaft attached to one or two bullocks. The pestle presses the safflower seedagainst the sides of the mortar, gradually separating the oil from the cake which forms on the sides. The oil may be led off a small duct from the bottom of the mortar, or it may accumulate in the mortar to be ladled out later after the removal of the rotating pestle. In India agricultural engineers have developed ghanis that are cheap to purchase and more efficient in operation than those of the villages. These are made from concrete, have a wooden linear, cost about $80.00, and will process up to 300 pounds of decorticated seed per day. A ghani was seen in Kabul, Afghanistan, that was used at times for safflower. One seen in Meshed, Iran, was not so used.

In Egypt prior to removing the oil in a press, the seed was (1) cracked with a stone grinder sufficient to loosen the hulls, and permit their removal with screens, (2) ground with a rolling round stone, and (3) placed in tight, flat straw baskets shaped like a beret. Several of the filled baskets were stacked one on top of the other, and pressure applied to the top with either a hand operated screw press or a heavy wooden lever. About 125 kilos of seed gave 20 kilos of oil.

It was reported to me by the villagers of the Isfahan area of Iran that the oil could be skimmed off after boiling a mixture of crushed seed and water.

The cake remaining after the extraction of the oil is used as a livestock feed.

Insects

Most cultivated safflower had some insect damage to the heads. In many cases the larvae of insects were present in heads that were not completely mature. There was not time to identify the insects involved, except to note that there were several different types. They were distinctly more damaging than insects in California.

The most serious insect pest was the larvae of the safflower fly (Acanthiophilus helianthi Rossi). This insect attacks both domestic and wild safflower. It appeared late in the development of cultivated safflower.

In the Hyderabad area of India the most serious insect pest was aphis (Macrosiphum jaceae (Linn.) In Turkey insect damage was severe, most heads exhibiting damage to some seeds. Heliothis is the most serious insect pest in Israel. Onion thrips may be troublesome in Egypt.

Diseases

Diseases did not appear to be serious in safflower at any location. Rust was often seen, but was never as severe as in California. At the Karaj Research Station near Tehran, Iran, some varieties introduced from the United States had suffered severely from some soil factors believed to be a disease, whereas the local materials remained quite healthy. Wherever safflower was over-irrigated some dead plants were seen, presumably being killed by Phytophthora root rot. This was true also of wild safflower (oxyacantha) in Pakistan. Reports or observations of other diseases are as follows:

(1) Alternaria and Cercospora have occurred together on safflower in the Hyderabad area of India, usually appearing about 25 days after emergence.

(2) Powdery mildew (Erysiphe) has been found on safflower in the Hyderabad area of India. What appeared to be the same pest was on safflower in Jordan.

(3) What is believed to be Cercospora leaf spot was seen on wild safflower (oxyacantha) in the Peshawar area of Pakistan.

(4) Sclerotium baticola has been serious in Israel after an irrigation and some late rain.

(5) In Israel there are two rust pathogens, Puccinia carthami and P. verruca. The latter produces a hard pustule surrounded by a halo. The introduced Syrian variety is resistant to both species. Near the Deir Alla Station in Jordan, wild safflower (C. glancus) was susceptible to rust, but the cultivated variety appeared resistant -- it was too late in the season to be positive about this resistance.

Reference has already been made to the abnormal types of safflower seen in Afghanistan and Jordan, where the heads grew vegetatively. It is believed that insects were involved in some way with this condition.

Improvement of safflower

Some research on safflower was underway in several countries, most of it along plant breeding lines. In no case was one found carrying out experiments on methods of production. A summary follows (page 15a) in table form of some of the work being done by research stations. This is in no sense the complete story of research on safflower in the countries visited, but it does outline rather fully the information which was obtained.

Publications on safflower

While visiting the Oilseeds Section of the Department of Agriculture at Poona, Bombay State, a manuscript was read of a Farm Bulletin written by Professor V. M. Chavan, Retired Deputy Director of Agriculture at the Poona Station, entitled "Safflower Cultivation in India". This bulletin will contain complete information on the culture, uses, pests and varieties of safflower in India. Professor Chavan has also written a monograph on safflower which is still in manuscript form, and which will be published by the Indian Central Oilseeds Committee, 'Gandhi Bevan', Hyderabad-1, India.

WILD SPECIES OF SAFFLOWER

Wild safflower species were seen over most of the route traveled, and many samples were collected (table 2). In India they were not seen in the areas east and south of Delhi. Upper Egypt appeared to be free of them also. The species varied from area to area.

Two of the wild species, oxyacantha and flavescens, were very serious weeds, the former being the worst of the two. It is interesting to note that they occupy different areas, and both are closely related to cultivated safflower.

All of the weedy species merit great care in testing them in the United States, lest they escape. It is believed, however, that they would yeild rather readily to good farm practices. Cultivation immediately after harvest of grains should destroy most of them before they bloom -- that is not a common practice in the Middle East because of the value of the stubble as pasture for sheep and goats. If sprayed with 2,4-D and other herbicides before they bloom, most of the wild species should be killed rather readily. Around Lahore, in West

(cont'd. page 16)

Station	In charge	Scope of research program
Substation, India Agric. Res. Inst., at Sugarcane Res. Inst., Pusa, India	Mr. S. A. Dadlani	Tests of introduced and Indian varieties. Hybridization among Indian varieties to obtain higher yield, earliness and spineless types.
Agric. Res. Inst. Rajenderonayar, near Hyderabad, India	Mr. Y.V.S. Krishnamurty	Tests of introduced and Indian varieties. Selection among Indian materials to obtain better spiny types.
Agricultural Res. Sta. Niphad, Bombay State, India	Mr. J. A. Patil	Selections within local materials.("N" = Niphad).
Agricultural College Lyallpur, West Pakistan	Mr. Zafar Alam	Tests of local and introduced varieties.
Agricultural Expt. Sta. Kabul, Afghanistan	Dr. A. Krochmal	Testing introduced varieties.
Agricultural Expt. Sta. Karaj, Iran	- -	Testing local and introduced varieties.
Experimental Farm Isfahan, Iran	- -	Tests of local varieties.
Experimental Farm, Meshed, Iran	- -	Tests of local varieties.
Abu Ghraib Expt. Sta. near Baghdad, Iraq	Mr. Hussaen Al Shakarji	Tests of local and introduced varieties.
Deir Alla Sta. Jordan	Mr. Y. Atiyeh	Tests of introduced and local varieties, and dates of seeding.
Dept. Field and Vegetable Crops, Rehovot, Israel	Mr. J. Kostrinsky	Tests of introduced and local varieties, dates of seeding, fertilizers, and irrigation.
University of Ankara Faculty of Agriculture	Dr. Kamil Ilisilu	Tests of introduced and local varieties.
Expt. Sta. near Eskisehir, Turkey	Mr. Rifat Gerek	Red flowered, spinless local varieties under test.
Giza Expt. Sta. near Cairo, Egypt	Mr. Mustafa Serry	Tests of local and introduced varieties. Selection for superior strains in local materials.
Hellenic Agric. Res. Larissa, Greece	Dr. D. A. Panos	Testing introduced varieties. Determining area of adaptation.

Pakistan, it was completely absent in some areas being intensively irrigated. It should be recalled, however, that two species, lanatus and baeticus, have been successful weeds in local areas under range conditions in California (6).

Wild species related to cultivated safflower

Work at the University of California (1) has indicated that the species oxyacantha and palaestinus are closely related to cultivated safflower. All three have the same chromosome number (2n-24), and all three will intercross readily to give fertile hybrids. It is believed that flavescens also belongs to this group because of its close similarity to palaestinus -- flavescens grown at Davis in 1958 had 12 pairs of chromosomes.

C. oxyacantha Bieb.

C. oxyacantha was found from Iraq to western India and from southern Iran and Iraq to the Russian and Siberian frontier. Herbaria studies would indicate that it may be found also in southern Russia and Siberia. It was not seen often at higher elevations, and it is presumed that colder temperatures of such locations prevent its survival, at least as a winter annual. However, it was seen in the Meshed Area and near Tabriz, in both areas where snow occurs during the winter. Where it was well adapted stands were so heavy that they were difficult to walk through.

It appears to thrive best where land is left idle, or used for grazing, after the harvest of wheat or barley. It is abundant on roadsides where the soil is slightly disturbed. Where land was used exclusively for grazing it was not a serious weed, or was absent altogether. An exception to this might be the Moghan Plain north of Tabriz in Iran, where this species was reported to be abundant on the uncultivated plains in seasons of ample moisture.

C. oxyacantha was rather uniform in appearance at any one location. Usually it was one to two feet in height, though near Ahvaz in the Khuzestan, Iran, plants in some fields were uniformly four to five feet high. Spines were uniformly long and yellow in color. Usually it was glabrous, but pubescent types were often seen, and sometimes they were more abundant than those that were glabrous. The pubescent types appeared to be later in development. Head diameter, excluding the outer bracts, was little more than one-fourth inch, except in the Tabriz area of Iran where it was one-half inch or more. Seeds were black or mottled in color, and no pappus was present except north of Peshawar, Pakistan, where a short pappus was found on seeds of a few plants. In the same area there were a few plants with white flowers, the only instance of any color other than yellow. Plants with vegetative heads were seen in Iraq (Abu Ghraib Station and North of Mosul), northern Pakistan and north of Kabul in Afghanistan. This would appear to be the same malady present in cultivated safflower in Afghanistan and Jordan. Some rust was seen in this species in several locations though never in amounts sufficient to permit selections for resistance.

C. flavescens Willd.

C. flavescens appears to have the same weedy role as oxyacantha in that it thrives in cereal crops grown during the winter, and was found in bloom but with some heads mature or nearing maturity when the cereal crops were ripe or already harvested. C. oxyacantha blooms over a much longer period, however, and must be rated a more serious weed. It was also found on roadsides where the soil had been disturbed. It was collected in central Turkey and Syria, and seen from the train in southern Turkey. A small island was found on top of a range of hills in central Iraq, between Qizil Riba and Shahraban. Herbaria studies indicate that it may be found in northern Jordan and eastern Lebanon.

In no case was overlapping observed between flavescens and oxyacantha. Even the island in central Iraq, with oxyacantha on either side of the range of hills, appeared to be isolated. It was not possible to learn whether or not the oxyacantha of northern Iraq overlapped with flavescens of southern Turkey and northern Syria. Some specimens in herbaria, all from northern Iraq and southern Turkey, appeared to be intermediate between the two species.

C. flavescens was rather uniform in appearance, and resembled oxyacantha superficially. It differed from the latter species in having pappus on the seeds, seed rhombic in cross-section rather than oval, short rather than long yellow spines, and long linear outer bracts. Flowers are a darker yellow than those of oxyacantha, earning for it the name "golden safflower" by some taxonomists. Heads on the average would be larger than those of oxyacantha.

C. palaestinus Eig.

C. palaestinus has been collected only in the desert areas of Israel south of Beersheba. Unfortunately it was too late in the season for the writer to find it. Because of a dry winter, vegetation was sparse in the desert, and sheep and goats had eliminated what there was.

Typically it would be intermediate between cultivated safflower and flavescens -- it differs from flavescens in having wider bracts and being slightly less spiny. An introduction of palaestinus to California some years ago proved to have both white and yellow flowers. Herbarium materials at the Hebrew University in Jerusalem were variable with some plants very much like flavescens. One may be led to assume that palaestinus is the product of hybridization between flavescens and tinctorius. It is not hard to believe that tinctorius may have been, or may still be, grown by the Arabs of that area, since it was found in other Arab villages of Israel. How flavescens reached southern Israel, so far from Syria and Turkey, is more difficult to explain, unless it were carried there by man.

Materials in western Iraq

In the desert of western Iraq a species of safflower was found that could not be assigned positively to either palaestinus or flavescens. Because of heavy grazing only very small plants, or small portions of plants, were obtained. Their environment and morphology would suggest that they belong to palaestinus. Future comparisons in uniform nurseries should make their identification possible. If this species is palaestinus, it would indicate that this species has a wide distribution, and that its origin as a consequence of hybridization between domestic safflower and flavescens is improbable. Because of its similarity to cultivated safflower it may in fact be the progenitor of the latter.

Wild species with blue or purple flowers

Wild safflower with flowers of various shades of blue or purple and having grey-green foliage was collected in the area from Iran west to Egypt and Greece. Collections were assigned to six species, though it was realized that the taxonomy of these species is confusing in the literature and in herbaria. Collections in the field did not fall into neat categories, and many appeared to have been derivatives of hybrids between two species. Until the collections are studied together in a nursery it will not be possible to name them definitely.

Four species from this group, glaucus (sometimes called anatolicus), syriacus (sometimes called glaucus var. syriacus), alexandrinus (not like the species in the area of Alexandria, Egypt), and tenuis have been studied at the University of California. All four have the same chromosomes number (2n=20), but they have not been studied adequately in crosses for firm statements on their relationships.

C. lanatus L.

C. lanatus extends over almost the entire area covered by wild species of the Carthamus genus. It was not found in Jordan, Syria or Israel, and herbaria studies would indicate that it is scarce or absent from these areas and from Lebanon also. Herbaria specimens had been obtained from Kashmir, but not from India. Though the writer could not identify wild safflower species in Greece because of the lateness of the season, several herbarium specimens had been obtained from that country. Herbaria studies indicated that it occurred in southern Asia, the southern half of Europe, North Africa, Ethiopia, and both the Canary and Madeira Islands.

This species was somewhat variable. Observations and herbaria studies would indicate that the common, or only, type in the eastern area occupied by this species differs in the following respects from typical lanatus: greater height, light yellow or white flowers instead of lemon yellow, longer and more patent bracts, and longer pappus. In Turkey this type with light yellow flowers was found in the interior, and the typical type in the western area from Bursa to Izmir. Somewhat

similar types from Cyprus have been termed lanatus ssp. creticus L. On some of the islands of, or areas bordering, the Mediterranean Sea, including Crete, Sicily, Majorca, Trieste and Cyprus, "lanatus" plants appeared intermediate between this species and baeticus. A type in Spain appearing like baeticus but having a larger head and shorter bracts than the latter species was named lanatus var. glabratum by Reverchon. Almost all the lanatus from the Canary Islands in herbaria is actually baeticus.

Ashri's studies (1) indicated that lanatus has 22 pairs of chromosomes, and he assumed that it was an amphiploid from a cross between species with 12 and 10 pairs of chromosomes. Certainly the opportunity for amphiploidy presents itself where the species with 10 and 12 pairs of chromosomes overlap in countries of the Middle East. Hybrids were seen, all of them sterile, between such species in the Khuzestan of Iran, in northern Iraq and in central Turkey. Doubling of the chromosomes in such hybrids should restore fertility, and would give rise to a type with 22 pairs of chromosomes.

C. baeticus Nym.

This is a distinct species, but often named lanatus in herbaria. It differs from lanatus by having less pubescence, heads smaller and more clumped, outer involucral bracts patent and longer than the flowers, and flowers cream or light yellow in color rather than lemon yellow as in typical lanatus. It is found in Spain, Morocco, and adjacent islands. Though named lanatus, many herbarium specimens from the eastern Mediterranean resemble baeticus or appear to be intermediate between these two species.

Ashri has shown (1) that baeticus with 32 pairs of chromosomes is an amphiploid from a cross of lanatus (22 pairs) and a species with 10 pairs. None of the species he worked with provided the characteristics needed to explain the differences between lanatus and baeticus. Herbaria studies would indicate that leucocaulos Sibth & Sm. would be the most likely species, provided it has 10 pairs of chromosomes. Unfortunately, leucocaulos was not found.

Other wild species

An attempt was made to obtain a number of additional species in Morocco and Spain, but only caeruleus and arborescens were found. Other species are required from northwestern Africa, and these have been listed under "Itinerary" (page 6).

Origin of cultivated safflower

Vavilov (8) believed that mountainous Afghanistan was one of the areas in which safflower developed as a cultivated plant, and Kupsow (7) felt that his own data supported this conclusion. From limited observations it would appear that safflower is not widespread in

Afghanistan, most of it being grown in the Kabul area. Though Herat in western Afghanistan was not visited, one would expect to find safflower there since it is close to the Meshed area in Iran where safflower is grown in most villages. In two mountain valleys of Afghanistan which were visited -- one west of Ghazni and the valley of the Panjshir River north of Kabul -- safflower was unknown. It is probable that safflower is grown north of the mountains in Afghanistan and adjacent to the border of Siberia. At least Kupsow has grown types from the adjacent areas of Siberia. In the Kabul area it is grown primarily for the oil, which would suggest that its culture was introduced from India.

The plateau area of Iran would seem to have known safflower for a longer period than Afghanistan. In this plateau area it is grown primarily for the flowers, the most ancient use of the crop.

Names of cultivated safflower

Local names for cultivated safflower varied greatly. Ashri (1) has assembled many from literature. Those which I encountered were as follows:

Country and areas	Names
India: Bihar State	Kusumba
Hyderabad area	Kusuma
Afghanistan: Kabul	Muswar
Ghazni	Kariza
Iran: Isfahan	Koshe or Kousheh
Tabriz	Zafaran-Golu (Turkish)
Meshed	Kajireh or Golzardu
Iraq, Jordan, Syria and Egypt (Arabic)	Qurtum, Gurtum, Osfur, or Asper.
Spain	Alazor, or Azafran romī

OTHER OIL CROPS

Some collections of other oil crops were made, and these are listed in table 2.* Many of these, and this is particularly true of India and Pakistan, were obtained through research stations. Some information on the distribution and culture of oil crops was supplied, and is incorporated below. It is only a sketchy treatment, at best. It should be mentioned here that the Indian Central Oilseeds Committee (Ministry of Food and Agriculture, Government of India), with offices at 'Ghandi Bevan', Hyderabad-1, India, will publish a series of monographs on separate oil crops. These are as follows:

* Pages 27a-b

Castorbeans: Dr. L. G. Kulkarni, Oilseeds Specialist, Andra State, Rajendranayar, Hyderabad.

Groundnut: Shri C. R. Seshadri, Joint Director of Agriculture, Madras 5.

Niger: Professor V. M. Chavan, 898, Radha Niwas, Poona 4, Bombay State

Rape and mustard: Dr. Dharmpal Sing, Economic Botanist (Oilseeds), Kanpur, Uttar Pradesh.

Diseases of oilseeds: Dr. R. S. Vasudeva, Head of the Division of Mycology, India Agricultural Research Institute, New Delhi.

Sesame: Dr. A. B. Joshi, Division of Botany, India Agricultural Research Institute, New Delhi.

Linseed: Dr. R. H. Richaria, Principal, College of Agriculture, Sabur, Bihar State.

Other publications seen were:

Vegetable oils and oilseeds. By the Commonwealth Economic Committee. 5 shillings. Her Majesty's Stationery Office, London, England. 1957.

Report on research on oilseed crops in India. By C. M. John. For the Indian Oilseeds Committee. 1949. (Now out of print).

Because these monographs will soon be available, no attempt has been made here to discuss the culture of oil crops in India, other than what has been said about safflower.

Castor beans:

Distribution and variability: Castor beans were seen throughout most of the travels in Asia and Africa, but were most abundant in India. In the warmer areas they were often grown about villages and on the margins of small fields as a perennial, when the stems would reach a diameter of about six inches. Efforts are being made to grow the perennial types commercially in Egypt and Jordan. The annual types were being grown commercially on a field scale in India and Morocco, and considerable research with this in mind had been accomplished in Egypt. Other areas where annual types were seen are as follows: in central and northern Iran as a border to other irrigated summer crops; as a small dryland field near Bursa, Turkey; and in experimental plots of several research stations.

They were grown on a wide variety of soils. Near Hyderabad, India, castor beans were planted on the poorer, shallower red soils, whereas safflower was grown on the heavier, richer, black soils. In Egypt they had been successful on the sandy and less fertile soils.

Non-shattering types were more common than expected. These are preferred in the Hyderabad area of India, in Egypt and, of course, in Morocco. They are preferred because the harvests may be less frequent with less field loss. Types with small to medium-sized seeds were preferred in Central India, it being felt by the cultivators that such seed contained more oil. In Egypt, Indian varieties were preferred, Hindi 12 showing most promise as an annual and Hindi 21 as a perennial. Hybrid varieties were being grown in Morocco. Types with red, pink or cream capsules appeared to be more common in Iran.

Culture: Considerable information was obtained on the culture of castor beans in Egypt, from Mr. M. Serry, in charge of research on oil crops at the Giza Experimental Farm, and this is given below:

(a) Two types are grown, the perennial and the annual, the former being grown for a period of about 4 years.

(b) The perennial type is grown in many areas of Egypt about buildings, and seems to be used primarily for shade. As a commercial crop, it would appear to be best adapted to areas of the Eastern Desert and Gaza Strip where moisture is limited -- no irrigations are given in these areas -- and the soil sandy. It is sown in February or March, with plants 2 meters apart each way. It will reach a height of 5 meters on both fertile and sandy soils, often with several branches reaching close to the ground, but the bulk of the foliage and the racemes in the upper part of the plant. The base of the plants will be 6 inches in diameter or even more after 3 years. The plants are not pruned. They are removed after about 4 years and used for fuel. The first pick is usually made in July, the second about 20 days later, and a third, if necessary, about 20 days after the second. About 1000 pounds of seed per acre per year are expected from the perennial type. Hindi 21 is the most promising variety.

(c) It is hoped that the annual castor bean will be adapted to all areas of Egypt where the soils are not too salty, the pH neutral, and the water level not too high -- that will include most of Upper Egypt and much of Lower Egypt.

(d) The annual type is sown preferably in the first two weeks of March in dry soil. It is irrigated once a week until emergence is completed. Getting stands quickly has been difficult, and soaking of the seed before planting has not helped too much. Three or four seeds are planted in holes 30 cm. apart in rows, with the rows 60 cm. apart. After emergence stands are thinned to 2 plants per hole.

(e) After emergence irrigations are given about every 15 days, the interval depending on the needs of the plants, until the completion of the first picking when they will stop.

(f) Harvesting will start in July and end in September, with a total of 3 harvests of dry capsules, and one last harvest of green capsules. This last harvest is low in oil -- 43% vs. 50% for the seed

from dry capsules -- and the germination is reduced. It is necessary to complete the harvest in September to permit the preparation of the land for winter crops. About 5 spikes per plant will be obtained in the first 3 dry harvests.

(g) It is expected that about 75 kilos of ammonium sulfate (20% N) per acre will be required, in most areas, and up to 200 kilos in poor or virgin areas. Tests are underway now to determine castor bean requirements for N, P and K.

(h) After berseem clover sown as a winter crop and plowed under after the first cut for hay, castor bean yields have been up to 1250 kilos per acre. After sugar cane they have been down to 400 kilos per acre. The average would be between 500 and 750 kilos per acre.

(i) The capsules are harvested by stripping them off or cutting off the raceme with scissors. They are put in a sack, and the sacks spread out in the sun to dry. Since indehiscent types are preferred to reduce the number of harvests, it is necessary to beat the capsules with sticks to remove the seed.

(j) The preferred annual variety is Hindi 12.

In Morocco the culture of castor beans is similar to that in California. Thanks to Mr. J. Cabanel and Mr. R. Aramand, both of the Organico Company (Societé Organico), the writer was able to obtain the following information:

(a) Organico has two experiment stations in Morocco, one at Souk-Sept, near Beni-Mellal, which was visited, and the other at Primsouss, near Agadir.

(b) This company has 600 acres of castor beans growing in Morocco, with 190 at Tadla, 270 at Doukkla, 80 at Rharb, and the balance scattered in other areas.

(c) Yields have been about 1 ton per acre (1,000 kg./ha.).

(d) Their best variety is CN, with 415 second, and B195 third.

(e) The beans are planted March 15 to April 15.

(f) A pre-irrigation is given, then ridges put up 1 meter apart. Planting is done by hand on top of the ridge, with 3 seeds being placed 50 cm. apart.

(g) When there are 2 to 3 true leaves, the plants are thinned to 1 every 50 cm.

(h) Ammonium sulfate (28% N) at 150 kg./ha. is applied after emergence, sometimes as a split application.

(i) Irrigations are given about every 12 days. About 1000 cu. meters are used per hectare in a season, or 3 acre feet. Irrigations stop in September, in time to permit the harvest of the beans and preparation of the soil for planting wheat in November.

(j) One or two machine cultivations are given, and one by hand.

(k) The crop is hand harvested. The first harvest is usually taken in late August, the second in mid-September, and the third and last in early October. Occasionally a fourth harvest is made in early November.

Uses:

In some areas, notably in Morocco and India, large amounts of castor beans were marketed as seed for export. Where it was processed locally, the oil was used for illumination, and lubrication for farm vehicles, usually ox carts in India. The pomace was used principally as fertilizer. As a fertilizer in India it was reported to repel the white ant. In India, too, the meal was used to clarify gur, the large blocks of raw sugar made from sugar cane.

The leaves are fed to livestock in Egypt, and this is the main use of the crop in the eastern desert of that country. Care must be used in introducing livestock to this diet. At the start it should make up only one-quarter of the ration, and the leaves should be dried about 2 days in the sun. It may be increased over a week to constitute the entire diet.

An attempt was being made at the Shadnager Research Station near Hyderabad, India, to develop a silk industry based on a silkworm that fed on the leaves of castor beans. The silk of the worm feeding on castor beans would not come off the cocoon as a single thread, and other methods of removing the silk fibers were being investigated. It was reported from the Pusa area of India that the leaves are sometimes used to tenderize meat. In the Meshed area of Iran farmers were reported to grow it because they felt that castor beans brought good luck -- but the seeds were processed for oil in a ghani which were seen in Meshed.

Diseases and insects:

Though castor beans were not examined too closely, they seemed to be rather free from diseases and insects. Diseases reported to occur in the Hyderabad area of India are rust, Phytophthora root rot and Cercospora leaf spot. Cercospora leaf spot is the most serious disease in Egypt, but no rust has been seen. In Egypt the most serious insect pests are the cotton worm (Prodenia litura) and the jassid.

Flax

Though flax is a minor crop in India and Pakistan, it is grown over a wide area of both countries. Much of it is marketed as seed, and is not processed locally. Seed could be obtained in most other countries, but the crop was even less important than in India and Pakistan. Its production appeared to be localized to some extent. It was important in a small area northeast of Tabriz, Iran, and again near Sulaimaniya in Iraq. Small amounts, probably a winter hardy type, were seen in all areas of Turkey visited. In most cases the flax would not give a yield above 8 bushels per acre. The seed was brown in most instances, but at the Lyallpur Agricultural College in Pakistan a "fawn-colored" seed was preferred. Varieties in India and Pakistan looked like the "Indian" varieties grown in the irrigated southwestern area of the United States. A variety from Morocco looked promising at the Abu Ghraib Station in Iraq. Disease did not seem to be a serious problem, though some rust and Fusarium wilt occurred in India and Pakistan.

Sesame

Sesame is an important summer oil crop in all areas from India to Egypt. Often it appeared unthrifty and would give a very low yield. It was usually seen only in the early bloom stage, so cannot say much about the variability in plant types. It was grown as the only crop in a field or as a border to some other crop. Usually it was a dry-land crop, but would be irrigated in some cases.

It was grown mostly for its oil. However, in Egypt and countries of the Near East it was used to make a very palatable product like peanut butter. This halawa in Egypt used about 75% of the total sesame production. For halawa, varieties with white seed and low oil content were preferred.

Some miscellaneous information on sesame is given below:

(a) A wild species of sesame is reported to grow in the northern part of Bombay State in India.

(b) The India Agricultural Research Institute in New Delhi reported that an indehiscent variety had been developed in Japan.

(c) The local selection tested at the Deir Alla Station in Jordan was highly resistant to root rot, though the pathogens involved had not been determined.

(d) Root rots were severe in Egypt, the pathogens being Rhizoctonia solani and Sclerotinia bataticola.

Mustards and rapes

Mustards and rapes were important as oil crops in India, Pakistan,

and Iran. No inquiry was made as to their culture and uses, but their wide distribution and success would suggest that they deserve more attention in the United States. It was surprising to see Eruca sativa, locally called Kaykoj, an important oil crop in central Iran. A tetraploid mustard induced by colchicine treatment looks very promising in Pakistan.

Sunflowers

In Afghanistan, Iran and Turkey sunflowers were abundant. Often they were used as borders about a field or as single rows perhaps 50 apart with other summer crops in between. Sometimes fields up to 10 acres in size were seen. More were seen in western Turkey than in any region, with about one-half of the acreage planted in summer crops being sunflowers. Mostly the plants were 5 to 8 feet in height, and mostly the seed was small to medium in size and variable in color. Multiple headed types were common. It would appear to be a dryland crop in most instances, but sometimes it was irrigated. The heads were harvested by hand, placed together in one place to dry, and beat with sticks to remove the seeds. In western Turkey some or much of the crop is used for oil, but mostly the seeds were roasted and salted for human consumption. Miscellaneous comments or observations on sunflowers are:

1. In Israel a large seeded Greystripe variety is grown to provide seeds for human consumption.

2. They have been grown in the area of Alexandria, Egypt, for export.

3. In Egypt a root rot, probably caused by Sclerotinia, has been severe.

4. Broomrape (species of Orobanche is a serious pest of sunflowers, and apparently has forced a large amount of the sunflowers from the Thrace region of Turkey to the area south of the Sea of Marmara.

5. Sunflower heads were remarkably free of insects, a great contrast to the situation in the United States.

6. Sunflower varieties are under test in Iran and Iraq.

Peanuts:

The production of peanuts would appear to be increasing in a number of countries. In Bombay State in India, by way of example, peanuts has become the most important oil crop, though it was introduced as late as 1910. In Egypt it follows cotton in importance as a source of oil. No particular effort was made to collect peanuts, since it was assumed that most types probably would be introductions from the United States.

Soybeans

In no area visited was soybeans grown commercially to the writer's

knowledge, and no soybean seed seen for sale. The four varieties from Iran were obtained from the agricultural experimental station near Isfahan.

Poppy

No particular effort was made to obtain poppy seed. It would appear to be widely grown in Iran, though the amount in any one area would be small. At one time it was an important field crop in the Meshed area of Iran, but its production is presently prohibited, and no other crop has been a satisfactory substitute. Seed was also obtained from Afghanistan and West Pakistan.

Niger

Niger seed was obtained only in India. It is a crop of waste lands, areas of low rainfall, and steep slopes. The yield will lie between 200 and 300 pounds per acre. Some attempt is being made to develop superior strains.

Prickly lettuce (Lactuca serriola)

In Egypt it was surprising to learn that a species of lettuce was being used for oil. The entire amount, however, is estimated to be about 300 acres, and it is grown in the areas of Upper Egypt that grow safflower. Like safflower the acreage is declining primarily because of the increasing production of cotton.

Two types are grown, one with light colored seed, and the other with dark. Its culture is the same as that of safflower.

OTHER FIELD AND VEGETABLE CROPS

Although seed was collected of other field and vegetable crops (table 2), no particular effort was made to obtain detailed information about their culture. However, it seemed appropriate to mention here some locations where species of forage crops appeared to be abundant, and where they had not been eliminated by grazing.

Traveling by train along the southern border of Turkey, with no opportunity to leave the train, there appeared to be a great variety of forage species. Though it had been a dry year in 1958, overgrazing was not apparent near the railway track. The landscape reminded one of the southern Great Plains, and the weather would be like areas of Arizona growing crops dryland. Wheat was the main crop. It would seem to merit the visit of a plant explorer during late May, June and perhaps early July.

In Iraq the most interesting area visited from the standpoint of forage species was north of Mosul in the vicinity of Sirsank. Here overgrazing was not pronounced, and a great number of species of grasses were present. Any detailed exploration of this area for forage

Table 2. Collections of safflower and other crop seeds by countries - 1958.

Crop or species	India	Pakistan	Afghanistan	Iran	Iraq	Jordan	Syria	Israel	Turkey	Greece	Egypt	Morocco	Spain	Portugal	Total
Carthamus															
C. alexandrinus											4				4
C. arborescens													2		2
C. baeticus												4	2		6
C. caeruleus									1			5			6
C. dentatus									17						17
C. flavescens					2		7		8						17
C. glaucus				9	13	3	1	4	7						37
C. hybrids ??				3	3	4		11							21
C. lanatus		9	5	14	5				15		2	15	15	3	83
C. nitidus						2	2								4
C. oxyacantha	14	68	12	44	42										180
C. spp.					4					17					21
C. syriacus						9	2								11
C. tenuis						2	3	15	2						22
C. tinctorius	125	75	16	53	4	13	6	4	15	1	36		10	62	420
Related genera		1	4	6	2		1		6		5	2	2		29
Other Oilseed Crops															
Castor beans	50	8		21				1	1		4	2			87
Flax	26	85		30	17	2	6		8		10				184
Sesame	23	6		19	3	2	3	2			11				69
Brassica	3	19	1	14	1						2				40
Sunflower				11	10			2	7		3		3		36
Peanut	14														14
Soybean				4											4
Poppy		2	1	6											9
Niger	15														15
Lettuce											4				4

Table 2 Continued.

Crop or species	India	Pakistan	Afghanistan	Iran	Iraq	Jordan	Syria	Israel	Turkey	Greece	Egypt	Morocco	Spain	Portugal	Total
Other Crops and Plants															
Wheat	2	18	13	26	6										65
Barley		11	9	14	4		3	1	3		1		1		47
Oats		1						1	1				1		4
Rye			1	5					2				1		9
Millet	1	7	7	10	2								1		28
Sorghum	3	10		5	2		1				4				25
Corn		3	4	2	1		3		1						14
Chickpea	1	4	2	5	2	2	2		3		1		2		24
Legumes*		4	20	41	19	1	4	2	10		4	5	7	1	118
Grasses		14	22	65	62			9	11	3	2	18	6	1	213
Miscellaneous	18	62	57	76	28	2	4	5	27		28	10	5	1	323
Total	295	407	174	483	232	42	48	57	145	21	121	61	58	68	2212

* Small seeded

SAFFLOWER SPECIES - (Carthamus)

	PI Numbers
C. alexandrinus	250455-57 250588
C. arborescens	253348-49
C. baeticus	253350-51 253587-89
C. caeruleus	253590-93
C. dentatus	251447-53 252009-17 254974-75
C. flavescens	252018-24 253842-48 254082-83
C. glaucus	249946-49 251254 251454 252525-30 253352-55 253849-61 254084-86
C. lanatus	249131 249950-53 250171-73 250458-59 250291-96 250698-703 250762-64 250811-12 250911-12 251455-61 252531-39 253356-68 253506-09 253594-608 253862-66 254087 255821
C. nitidus	253867-70
C. oxyacantha	248343-54 249954-80 250174-78 250460-72 250297-334 250589-94 250704-07 250765-73 250813-18 250913-19 251023 253738-51 253753-57 253872-84 254088-89 254883-84 255822-23
C. syriacus	251255-61 253885-88
C. tenuis	253369-83 253889-91
C. tinctorius	248355-89 248623-34 248793-880 250006-12 250075-83 250179-208 250473-84 250335-54 250523-41 250595-611 250708-24 250774 250819-42 250920-26 251262-68 251284-91

	PI Numbers
C. tinctorius (cont'd.)	251462
	251977-87
	252540-42
	253384-96
	253510-71
	253758-65
	253892-97
	253898-916
	254090
	254976

	PI Numbers
C. spp.	250000
	250013-16
	250209
	250355-56
	251398
	251988-89
	252543
	253397-408
	253609-10
	253752
	253766-69
	253917-22
	254977-90

MISCELLANEOUS OILSEEDS

	PI Numbers
Arachis hypogaea	248755-68
Brassica campestris	251235-37
Brassica campestris var. sarson	251238
Brassica juncea	248769 251239
Brassica napus	251240
Brassica rapa	250004 251022 251513
Brassica spp.	248770 250129-40 251241 251326 253722 254540-45
Eruca sativa	250149-52 251489-99 251788-89
Eruca sp.	255664
Helianthus annuus	250019 250085 250542 250612 250726 250850-56 251464-66 251990-93 253414-18 253771-78 253931-32
Linum angustifolium	253971
Linum strictum	250216-17 250368 253972
Linum usitatissimum	248636-38 248902-25 248989-93
Linum usitatissimum (cont'd.)	250088-93 250218-24 250369-87 250492-518 250543-70 250614-21 250730-38 250862-72 250932-34 251292-93 251469-72 251995-98 253781-85 253942-48 253973-82 254897
Ricinus communis	248390-94 248926-70 250026-28 250098 250225-26 250396-98 250573-75 250622-24 250742-43 250874-84 250938-42 252001 253422 253620-21
Sesamum indicum	248971-88 249132-34 250029-32 250099-103 250227-29 250399-401 250519 250576-80 250625-26 251294-95 253423-24 253792-94 253983-85
Sesamum orientale	250748-49 250886-95 250944-46

CEREAL AND GRAIN CROPS

	PI Numbers
Avena byzantina	250646
Avena sativa	252008
	253347
Avena sp.	253501
Hordeum vulgare	248635
	250489-90
	250613
	250652-53
	250727-29
	250775-78
	250857-61
	250931
	251269
	251467-68
	251994
	253574
	253934
	255824
Hordeum spp.	249984-88
	250364-67
	250491
	251387
	253780
	253935-41
	254895
Secale cereale	250744-47
	250885
	252002-03
	254911
Sorghum vulgare	248989
	250033
	250230-34

	PI Numbers
Sorghum vulgare (cont'd.)	250402-06
	250520-21
	250581-83
	250750
	250896-98
	253795-96
	253986
Triticum aestivum	250039-50
	250236-37
	250408-14
	250584-86
	250628-33
	250754-56
	250791-95
	250900-05
	250949-50
	251397
	253799-804
	253958-63
	253997
	255826-27
Triticum compactum	250757
Triticum dicoccum	248990-91
Triticum durum	250951
	253964
Triticum spp.	254918-19
Zea mays	250052
	250239
	250417-18
	250798-800
	250907
	252005
	253811
	254007-010

	PI Numbers
Ocimum basilicum	253157-58 254352
Papaver somniferum	250640 251083 252159-63 253286-87
Papaver spp.	250641 252164
Pimpinella anisum	254353
Plantago psyllium	253165
Plantago spp.	253166-67
Prunus sp.	254560
Rubia tinctorius	253168
Rubus spp.	250169-70 254563
Rumex spp.	250642-43 251039-40 251230 252169 254564
Salvia sp.	253170
Scabiosa spp.	254354-55
Xeranthemum annuum	253488
Undertermined	253170-72 253180 253721 255641

FORAGE GRASSES

	PI Numbers
Aegilops columnaris	254860-62
Aegilops cylindrica	254863
Aegilops longissima	254864
Aegilops speltoides	254865
Aegilops triuncialis	250696 250908 254859
Agropyron cristatum	250909-10
Agropyron orientale	251249 251378-79
Agropyron panormitatum	254866
Agropyron spp.	251443 253334 254867-68
Agrostis alba	251250
Agrostis sp.	251251
Alopecuris pratensis	251380
Andropogon intermedius	253335
Andropogon ischaemum	251252 254869
Andropogon spp.	250644 251444 251975
Andropogon annulatus	250003
Aristida coerulescens	250645
Aristida pinnata	251215
Arrhenatherum erianthum	254870
Brachypodium spp.	250647 251445 253336 253502-03 254973
Briza spp.	254871-72
Bromus catharticus	250648
Bromus danthoniae	254873-74
Bromus hordaceous	250005
Bromus japonicus	250649-50 250697
Bromus mollis	250760-61 253337 254875-77
Bromus pseudodanthoniae	253504
Bromus rigidus	254878
Bromus squarrosus	254879-80
Bromus tectorum	251216
Bromus spp.	251217-18 251381 251976 252052 253505 253735-37 254881-82 255820
Calamagrostis sp.	250651
Chrysopogon sp.	254885-88

	PI Numbers
Cynodon dactylon	254890-92
Dactylis glomerata	250725 250843 250929-28 253409-13 253612-16 253966-67 254991-92
Dactylis spp.	250929 251382 251463 253572
Echinochloa crusgalli	250215
Eleusine coracana	248881
Festuca elatior	251383
Festuca rubra	251384-85
Festuca sp.	251386
Glyceria sp.	254893
Hordeum bulbosum	250930
Hordeum spontaneum	249983 253573 253933 254894
Imperata sp.	254896
Lagurus ovatus	253338
Lolium perenne	251473 254898-99
Lolium sp.	250023
Melica cupana	251272
Oryzopsis coerulescens	253339 253575-76
Oryzopsis holciformus	254900-01
Oryzopsis miliacea	253340-43 253577-78
Oryzopsis spp.	253787-88
Panicum miliaceum	250025 250096 250391-92 250785-88 251273 251388-89 251403-06 253421 253789-90 253953-55
Panicum sp.	250654
Pappophorum sp.	250655
Pennisetum spicatum	250393-95 250656
Phalaris canariensis	250097 250741 251274 251390 251475
Phalaris minor	249997
Phalaris paradoxa	253579
Phalaris tuberosa	254902-04
Phalaris spp.	249998-99 252000
Phleum sp.	251391 251476 254905
Poa bulbosa	251275 251392-93 253791 254906-07

	PI Numbers
Poa pratensis	250657 251276 251394 253580
Poa spp.	251277-78 251407 253956-57 254908-09
Puccinellia distans	251220
Puccinellia sp.	254910
Secale villosum	251477-78
Secale sp.	250943
Setaria italica	251395
Sorghum sudanensis	250104
Stipa bromoides	253581
Stipa pinnata	253797
Stipa spp.	250751-52 250947 253344
Themeda anathera	250658

FORAGE LEGUMES

	PI Numbers
Astragalus sp.	250290 253734
Canavalia ensiformis	250074
Crotalaria juncea	250485-87
Ebenus pinnata	253617-18
Hedysarum coronarium	250361
Lathyrus sativus	253968-70
Lotus corniculatus	250571
Lotus spp.	251270 251400 253419
Lupinus albus	250094 250572
Medicago aschersoniana	250388
Medicago hispida	250389-90
Medicago lupulina	250739 251271 251401
Medicago orbicularis	251474 253786
Medicago sativa	249994-96 250935-36 251329 251402 253420 253619 253949-51
Medicago spp.	250095 250740 250779-82 253952
Melilotus officinalis	250937
Melilotus spp.	250783-84 250873
Onobrychis viciaefolia	250024
Trifolium alexandrinum	250105 250659 253582 253798
Trifolium angustifolium	251479 253345-46
Trifolium campestre	250034 251480 253987 254912
Trifolium fragiferum	250789 251408 251481-82
Trifolium hirtum	254913
Trifolium lappaceum	251483
Trifolium patens	250753
Trifolium pratense	250899 250948 251279 253582
Trifolium repens	250407 250627
Trifolium resupinatum	250035-38 251396 251409-11 253988-91
Trifolium spumosum	253992

	PI Numbers
Trifolium spp.	250790
	251280
	251484
	253584-85
	253993-95
	254914-17
Trigonella foenum-graecum	250106
	250235
	251281
	251412
	253996
Vicia ervilia	251413
	252053
	253805
	253998-99
Vicia faba	251231-32
	251330-31
	252004
	253425
	253806-09
	254000-006
	254920
Vicia sativa	251414
Vicia sativa (cont'd.)	253426-27
	254921
Vicia villosa	251282
Vicia spp.	250758
	250796-97
	251221
Vigna cylindrica	250238
	250415
Vigna sinensis	250051
	250107
	250416
	250522
	250587
	250634
	250759
	250906
	251222
	251233
	253428
	253810
Vigna spp.	250844-47
	254922

VEGETABLES

	PI Numbers
Allium cepa	248753-54 249085-86 251020-21 251325 251508-09 254533
Allium porrum	249548 254534-35
Allium spp.	251510 252224-25 253463-65 254536-38
Apium graveolens	254539
Beta vulgaris	251511-12
Brassica oleracea var. botrytis	250127-28
Brassica sp.	249549
Capsicum frutescens	250141 254546 255660-61
Cicer arietinum	249981-82 250142-44 250210 251024-27 251226-27 251242-43 251514 252226-28 253466 253723 254547-50 254889
Citrullus vulgaris	250145-46 251244 251515 255662
Cucumis melo	250147 251028 251516-17
Cucumis melo var. flexuosus	254551 255663
Cucumis sativus	249550 251518-21
Cucurbita pepo	251791
Daucus carota	251228 251522 254552
Hibiscus esculentus	250126 251500
Lactuca sativa	251501
Lactuca serriola	250020 251245-47
Lactuca spp.	253229-30 255665
Lens culinaris	250153-58 251029-32 251248 254553-54
Luffa acutangula	254555
Luffa aegyptiaca	250160
Petroselinum crispum	251502
Phaseolus aureus	249551-52 250161-62 251033-36 251229 253724 254556-59 255825

	PI Numbers
Phaseolus mungo	250163-64
Phaseolus vulgaris	249553-54 250165-66
Portulaca oleracea	251503
Raphanus sativus	250167-68
Raphanus sativus (cont'd.)	250137-38 251504-05 254561-62
Solanum melongena	251506
Spinacia oleracea	251507 254565

FIBER CROPS

	PI Numbers
Cannabis sativa	251219 251253 251446 253965
Corchorus olitorius	250084
Cyamopsis tetragonolobus	250211-14 250357-60
Gossypium	250848-49
Hibiscus cannabinus	248895-901 250086-87 250362-63 250488
Hibiscus sp.	251399

MISCELLANEOUS

	PI Numbers
Alyssum sp.	253139
Ammi copticum	249114 252140-41 254347-48
Anethum graveolens	253142
Anthemis sp.	250635
Bixa orellana	255640
Bupleurum sp.	253143
Carduus sp.	254349
Centaurea depressa	251077
Centaurea moschata	251078
Centaurea spp.	250017 251079-80 253144 253279-82 253479-86 253770 255639
Cephalaria sp.	250018
Cleome sp.	255638
Cirsium sp.	254350
Coriandrum sativum	249115-16 250636 253145-46
Cotinus coggygria	250637
Cuminum cyminum	254351
Cynara sp.	253611
Delphinium sp.	253147-48 253179-80
Descurainia sophia	251523
Diospyros sp.	250148
Dipsacus sp.	253283
Filago sp.	253149
Foeniculum vulgare	253150-51
Glaucium corniculatum	253284
Guizotia abyssinica	248892-94
Iris sisyrinchium	253779
Iris sp.	253152 253487
Lallemantia sp.	253153
Leontodon sp.	250638
Lepidium latifolium	250021
Lepidium sativum	250022 250159 253154
Lilium sp.	253155
Mallotus philippensis	250639
Nicotiana tabacum	251999
Nigella sativa	251081-82 252156
Nigella sp.	253285